RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2004	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research			R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, R-1 #2				
COST (In Millions)	FY 2003	FY2004	FY2005	FY 2006	FY 2007	FY 2008	FY 2009
Total Program Element (PE) Cost	171.383	139.434	143.729	146.565	148.723	151.339	153.893
Bio/Info/Micro Sciences BLS-01	77.733	43.855	63.437	77.679	79.029	78.948	79.843
Information Sciences CCS-02	20.306	21.194	23.791	23.592	23.565	23.547	23.528
Electronic Sciences ES-01	17.568	26.449	25.465	21.809	22.678	25.416	27.118
Materials Sciences MS-01	55.776	47.936	31.036	23.485	23.451	23.428	23.404

(U) Mission Description:

(U) The Defense Research Sciences Program Element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term National Security enhancement through the discovery of new phenomena and the exploration of the potential of such phenomena for Defense applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic, biological and materials sciences.

(U) The Bio/Info/Micro Sciences project will explore and develop potential technological breakthroughs that exist at the intersection of biology, information technology and micro/physical systems to exploit advances and leverage fundamental discoveries for the development of new technologies, techniques and systems of interest to the DoD. Programs in this project will draw upon information and physical sciences to discover properties of biological systems that cross multiple length scales of biological architecture and function, from the molecular and genetic level through cellular, tissue, organ, and whole organisms' levels. Key focus areas include multidisciplinary programs in BioComputational Systems; Simulation of Bio-Molecular Microsystems; Bio Futures; Biological Adaptation, Assembly, and Manufacturing; Nanostructure in Biology; and Human Assisted Neural Devices.

(U) The Information Sciences project supports basic scientific study and experimentation for national security requirements such as computational models, new mechanisms for performing computation and communication, innovative approaches to the composition of software, novel human computer interfaces, novel computing architectures, and automatic speech recognition research.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, R-1 #2

(U) The Electronic Sciences project explores and demonstrates electronic and optoelectronic devices, circuits and processing concepts that will provide: (1) new technical options for meeting the information gathering, transmission and processing required to maintain near-real time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near-real time; and (2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities.

(U) The Materials Sciences project is concerned with the development of: high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or bimolecular materials, interfaces and microsystems; materials and measurements for molecular-scale electronics and spin-dependent materials and devices.

(U) **Program Change Summary:** *(In Millions)*	**FY 2003**	**FY 2004**	**FY2005**
Previous President's Budget	199.030	151.029	143.522
Current President's Budget	171.383	139.434	143.729
Total Adjustments	-27.647	-11.595	0.207
Congressional program reductions	0.000	-35.495	
Congressional increases	0.000	23.900	
Reprogrammings	-17.039	0.000	
SBIR/STTR transfer	-10.608	0.000	

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Applied Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E

(U) Change Summary Explanation:

FY 2003	Decrease reflects below threshold reprogrammings and SBIR transfer.
FY 2004	Decrease reflects congressional reductions to biological programs and undistributed reductions offset by congressionally added funds in the areas of nanotechnology, photonics and spin electronics.
FY 2005	Increase reflects minor program re-pricing.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Bio/Info/Micro Sciences BLS-01	77.733	43.855	63.437	77.679	79.029	78.948	79.843

(U) Mission Description:

(U) This project will investigate and develop the intersections of biology, information technology and micro/physical systems to exploit important technological advances and leverage fundamental discoveries for the development of new technologies, techniques, and systems of interest to the DoD. This research is critical to the development of rapid responses to engineered biological warfare agents, radically new biomolecular computers, and novel materials for the DoD. Programs in this project will draw upon the information and physical sciences to discover properties of biological systems that cross multiple scales of biological architecture and function, from the molecular and genetic level through cellular, tissue, organ, and whole organism levels. This project will develop the basic research tools in biology that are unique to the application of biological-based solutions to critical Defense problems.

(U) Program Accomplishments/Planned Programs:

	FY 2003	FY 2004	FY 2005
BioComputational Systems	24.000	8.000	9.237

(U) The BioComputational Systems (BioComp) component seeks to use computation to enhance biology, and to use biology to enhance computation. The BioComp program will explore revolutionary, high-speed methods for use by field commanders to predict biological warfare threats. Requiring only minutes, these computer prediction methods will give warfighters far more information about biological threats faster than today's costly wet-lab technology.

(U) In a related thrust, enhancing biology by using modern computation, the program will develop validated computational models of internal cellular processes, capturing complex gene and protein interactions, and simulation tools, for in-silico analysis, capable of predicting cellular spatiotemporal dynamics. In addition to enabling high-speed methods for commanders to predict threats from biological warfare agents, the program will develop new technologies for the rapid and environmentally safe decontamination of spore-forming bacteria like anthrax in the field.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

The application realm includes characterization, prediction, and control of biomolecular processes such as those related to pathogens; mechanisms such as circadian rhythms that underlie war fighter performance and well-being in stressed conditions; and design of bio-sensors. This program will also pursue a comprehensive cognitive system that supports rapid analysis and discovery of molecular and cellular level mechanisms underlying pathogenesis relevant to biological threats, and the discovery of potential intervention mechanisms. The modeling and simulation capability will be extensible from cell level to higher levels such as organ, organism, and to collective groups of organisms. In addition, the program will begin leveraging modeling, simulation, and bio-informatics capabilities to explore new methods of biologically inspired computing principles, architecture, and design of robust and reliable information processing and networking systems.

(U) Program Plans:

- Initiate development of a progressively sophisticated suite of dynamic cellular models and architecture for Bio-SPICE (Simulation Program for Intra-Cell Evaluation), which will enable modeling, prediction, and control of last submission "cell model" processes, with continual validation of each model experimentally. The cell modeling and Bio-SPICE will be capable of analysis of hundreds of gene-protein networks and interactions.
- Continue to incorporate spatial models into Bio-SPICE and explore potential reduced-order models capabilities to analyze the non-linear and stochastic dynamics of thousands of interactions for sophisticated analysis of pathogenic agents.
- Investigate scalable and extensible implementation of Bio-SPICE that utilizes a distributed computing architecture supporting a rich set of spatio-temporal models, with the ability to handle vast amounts of experimental data for prediction and analysis.
- Identify candidate biosystem elements for intervention strategies in sporulation, cell cycle control, and other processes in defense against bioagents.
- Investigate the extension of research in knowledge representation and reasoning tools to integrate data and models across multiple scales.

	FY 2003	FY 2004	FY 2005
Simulation of Bio-Molecular Microsystems (SIMBIOSYS)	12.676	9.000	9.000

(U) The Simulation of Bio-Molecular Microsystems (SIMBIOSYS) program will focus on methods to dramatically improve the interaction and integration of biological elements with synthetic materials in the context of microsystems. Specifically the SIMBIOSYS program will

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

develop methods and tools to simulate and design Bio-Molecular Microsystems with a high degree of multi-disciplinary integration. This will be accomplished by exploring fundamental properties and compatibility of biological elements at the molecular surface level through experimental and theoretical analyses. Key phenomena to be studied include molecular recognition processes, signal transduction phenomena, and micro- and nano-scale transport of biological molecules. Engineering of biological systems may be used to manipulate these fundamental characteristics and optimize the integration of biological elements with synthetic materials for information collection. It is expected that significant advancements in devices that utilize or mimic biological elements will be realized including sensors, computational devices and dynamic biological materials for force protection and medical devices.

(U) Program Plans:

- Demonstrate high (signal to noise [SNR] ratio > 10) transduction of molecular signals into measurable electrical and mechanical signals using nanopores, micro/nano-cantilevers, and nanoparticles; demonstrate SNR ~ 100 using solid-state nanopores for DNA translocation and using nanopores for ultraselective DNA detection; demonstrate models to correlate transduced signal intensity to bio-molecular structure and binding events.
- Demonstrate low power transport (~ 10X reduction in power) of fluids by modulating surface tension in droplet based transport.
- Demonstrate surface-tension modulated transport of droplets on a substrate; demonstrate computational models to optimize transport characteristics.
- Demonstrate orders of magnitude (> 100X) improvement in microfluidic mixing using electrokinetic and Magneto Hydrodynamic (MHD) schemes (based on modeling studies); demonstrate 10 – 100 X improvement in mixing through MHD and electrokinetic instability mechanism.
- Develop scaling laws and phenomenological models for bio-molecular phenomena such as molecular recognition, signal transduction and bio-fluidic transport processes in bio-microfluidic systems; develop and implement scaling laws into microfluidic system modeling software to enable design of lab-on-a-chip systems.
- Design novel hybrid macro-molecular devices that form specific and controlled transducing functions at the molecular scale; demonstrate design of maltose binding proteins and ion channels with desired selectivity and sensitivity using computational tools.
- Design and demonstrate working devices that incorporate biological elements as sensors, actuators and computational devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

	FY 2003	FY 2004	FY 2005
Bio Interfaces	9.997	5.655	10.000

(U) The Bio Interfaces (formerly Bio Futures) program will support scientific study and experimentation, emphasizing biological software computation based on biological materials and physical interfaces between electronics and biology, and interactive biology. It will apply information technology to accelerate the analysis and synthesis of biological processes. The seamless integration of information technology and biological processes will provide the ability to exert computational control over biological and chemical processes. The Bio Futures program will also support the development of genomics-based platforms for enhancing the capabilities of biological systems to manufacture, sense, or compute.

(U) Program Plans:

- Manufacture the world's smallest nanofluidic channels (~2 nm in diameter) for parallel processing of single biomolecules; create microfluidic devices for trapping developing insect embryos for analysis of biological materials (e.g., pathogens); create a multi-cantilever field effect transistor for measuring single cell physiology.
- Develop new algorithms based on wavelets and superparamagnetic resonance for sorting neuronal spike data; develop a Bayesian network framework for analysis of cellular regulatory networks; develop a hybrid computational model for representing tissue differentiation; develop a software tool for analysis of high dimensional gene expression data.
- Demonstrate and validate novel nano- and micro-devices for measuring biological systems at the single cell and tissue level.
- Demonstrate and validate novel mathematical tools for analyzing and interpreting complex data sets obtained from complex biological systems.
- Develop mathematical approaches and new microelectronic devices for attacking biological problems including epidemiology and real time identification of biochemical markers.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

	FY 2003	FY 2004	FY 2005
Biological Adaptation, Assembly and Manufacture	9.500	5.200	11.200

(U) The Biological Adaptation, Assembly and Manufacturing program will examine the structure, function, and informational basis underlying biological system adaptation, particularly to harsh environments, and the factors employed by the organism to assemble and manufacture complex biological subsystems. The unique stability afforded biological systems in their ability to adapt to wide extremes of physical and endurance (e.g., heat, cold, and sleeplessness) parameters will be examined and exploited in order to engineer stability into biological systems of Defense needs (such as blood or other therapeutics). In addition, the fault tolerance present in biological systems will be exploited in order to assemble and manufacture complex physical and multi-functional systems, both biological and abiotic. Further activity in this area will investigate the communication between adaptive elements within biological systems, including biofilms, as they develop in space and time, and uncovering the fundamental informational and physical architectures that underlie this unique biological property. Applications to Defense systems include the development of highly adaptive, non-linear robust systems as well as chemical and biological sensors.

(U) Program Plans:

- Identify promising strategies in nature that allow organisms to survive under environmental extremes and adapt those strategies to other cells, tissues, organs and organisms, including platelets and red blood cells.
- Develop methods for selectively reducing metabolic requirements in a reversible manner following injury to extend the period of survival from injury to initiation of treatment.
- Demonstrate and validate that cells and organisms can be engineered to respond to environmental chemicals and toxins of interest to DoD by producing signals (colors, fluorescence) that can be detected remotely.
- Develop approaches for engineering biofilms for a variety of DoD applications including sensing; reporting and removing agents of interest from the environment; power generation; and systematically evaluating mechanisms of biofilm induced failure in metals, welds, and fabrications methods due to corrosion.
- Develop methods for designing and using biological molecules to assemble functional opto-electronic bandgap materials.
- Develop methods to heal limb-threatening wounds without loss of function through blastema formation and multiple tissue regeneration.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Demonstrate the adaptation of bacteria to the digestion of cellulose in disaccharides to enable the ability to use cellulose (e.g., grass) as nutrition.

	FY 2003	FY 2004	FY 2005
Nanostructure in Biology	9.560	9.000	12.000

(U) The Nanostructure in Biology program will investigate the nanostructure properties of biological materials to better understand their behavior and accelerate their exploitation for Defense applications. The tools and approaches developed under this program will also have a significant impact in a variety of critical, non-biological Defense technologies that rely on phenomena occurring at the nanoscale level. For example, the 3-D Atomic Resolution Imaging program will develop new instrumentation, computational tools and algorithms for real-time, atomic level resolution, 3D static or dynamic imaging of molecules and nanostructures. This new information about biomolecules will provide important new leads for the development of threat countermeasures, biomolecular sensors and motors, and molecular interventions to maintain human performance in the battlefield. This tool will help with detailed knowledge of doping profiles and defects. It might be possible to use these techniques to measure and control individual atoms or spins. In addition, research will be conducted in the interaction, at the nanoscale, of biotic and abiotic materials and functions.

(U) Another aspect of this program will examine the use of nanostructured magnetic materials to understand and manipulate cells and tissues, enhancing their capabilities to serve as sensors and/or regulatory pathways. The Bio-Magnetics Interfacing Concepts (BioMagnetICs) program will explore nano-scale magnetism as a novel transduction mechanism for the detection, manipulation and actuation of biological function in cells and single molecules. The core technologies to be developed will focus on the many technical challenges that must be addressed in order to integrate nano-scale magnetism with biology at the cellular and molecular level, and to ultimately detect and manipulate magnetically "tagged" bio-molecules and cells. These programs will present unprecedented new opportunities to exploit a wide range of bio-functionality for a number of DoD applications including chemical and biological sensing, diagnostics and therapeutics.

(U) Program Plans:
- Demonstrate proof of concept for using nanomagnetics to detect and manipulate individual cells and biomolecules.
- Demonstrate detection of a single electron spin using a cantilever-based magnetic resonance force microscope.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Develop and demonstrate biocompatible, nanomagnetic tags, sensors, and tweezers that will enable magnetics based detection, manipulation, and functional control of single cells and biomolecules.
- Demonstrate single nuclear spin sensitivity.
- Investigate fundamental issues of nanowire communication with electrically active biological systems (neurons) including high density recording, information processing, stimulation patterns, and new computational methods of analysis.

	FY 2003	FY 2004	FY 2005
Human Assisted Neural Devices (formerly Brain Machine Interface)	12.000	7.000	12.000

(U) This program will develop the scientific foundation for novel concepts that will improve warfighter performance on the battlefield as well as technologies for enhancing the quality of life of paralyzed veterans. This will require an understanding of neuroscience, significant computational efforts, and new material design and implementation. Closed-loop control of peripheral devices using brain signals will be examined. Examination of different brain regions will be accomplished in order to generate coded patterns to control peripheral devices and robotics. Techniques will be examined to extract these signals non-invasively. This effort will be conducted with the Veteran's Administration to ensure approaches are compatible with prosthetic requirements.

(U) Program Plans:

- Extract neural and force dynamic codes related to patterns of motor or sensory activity required for executing simple to complex motor or sensory activity (e.g., reaching, grasping, manipulating, running, walking, kicking, digging, hearing, seeing, tactile).
- Determine necessary force and sensory feedback (positional, postural, visual, acoustic, and other) from a peripheral device or interface that will provide critical inputs required for closed-loop control of a working device or prosthetic.
- Explore new methods, processes, and instrumentation for accessing neural codes non-invasively at appropriate spatiotemporal resolution to provide closed-loop control of a peripheral device.
- Demonstrate real time control under relevant conditions of force perturbation and cluttered sensory environments (e.g., recognizing and picking up a target and manipulating it).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Information Sciences CCS-02	20.306	21.194	23.791	23.592	23.565	23.547	23.528

(U) **Mission Description:**

(U) This project supports scientific study and experimentation on new computational models and mechanisms for communication for long-term national security requirements. This project is also exploring innovative approaches to the composition of software, novel means of exploitation of computer capabilities, practical logical and heuristic reasoning by machine and the development of enhanced human-computer interface technologies.

(U) **Program Accomplishments/Planned Programs:**

	FY 2003	FY 2004	FY 2005
Computer Exploitation and Human Collaboration	20.306	21.194	23.791

(U) The Computer Exploitation and Human Collaboration program will develop information processing technologies that allow warfighters and commanders to interact with computers in an intuitive and transparent fashion, and enable collaborations as well as intelligent exchange of information in a seamless manner. Architectures for software agents (including mobile code), redesign of classical computer operating systems, and secure exchange of information over insecure channels are some of the technical challenges in this area. Database currency and management of dynamically changing state are the important areas of research in pervasive computing. This program will explore new human-machine interaction paradigms, where the warfighter's or commander's goals and capabilities are reasoned about and used to drive the interaction. Research will address information overload and simplify user interfaces to effectively enhance military performance by providing concise, salient situation awareness. The creation of powerful multi-agent systems and tools for effective decision-making and analysis in complex multi-participant environments will also be addressed. High-performance, user-centered interfaces, which will be capable of understanding the warfighters' and commanders' combined natural communication and activity patterns, will also be explored. In particular, fundamental technology for integration of information expressed in different modalities will be developed. Overall, the program will provide vastly expanded power and improved efficiency of interaction for a wide range of military tasks and environments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) In the last two decades, research on machine intelligence has revealed that many reasoning problems have inherent computational complexity. More sophisticated heuristic approaches are needed to deal effectively with the complexity problem. Research in Real-World Reasoning will develop foundational technologies and tools necessary to enable effective, practical machine reasoning about complex, large-scale problems. The program will pursue innovative techniques in reasoning algorithms in terms of scale of the problems, speed of response, and correctness. This research will push the envelope of deep reasoning in decision-making by systematically taking into account interaction amongst multiple teams of warfighters, robots, and weapon systems in strategic settings with each team having different or varying goals. Among the key elements needing investigation are technologies for effective, practical inferential reasoning over information of real-world complexity and uncertainty. Novel paradigms for learning from experience and for capturing events and actions that affect the final outcome of a situation or scenario will be addressed. The difficult research challenges to be addressed by the program include the integration of multiple reasoning paradigms; representation and reasoning with information that changes constantly over time; reasoning about the goals of other agents; pragmatic reasoning that uses appropriate default assumptions and always does something reasonable; and appropriate metrics for measuring cognitive behavior and performance.

(U) Program Plans:

- Develop new forms of human-computer interaction that enable human and computers to work as synergistic teams.
- Investigate an adaptive visual and audio processing and display capability to maximize pertinent information conveyance that improves perception comprehension, retention, inference and decision-making.
- Explore cognitive models for integrating users' natural communication modalities (e.g., spoken language, gesture, and gaze) for a new class of interfaces.
- Develop adaptive multimodal processing techniques tailored to the user, task, and environment, assessing performance and usability advantages within multimodal systems developed in the program.
- Establish data-type standards for multimodal input devices (in support of plug-and-play and system-independent design).
- Develop methods for combining statistical and knowledge-based reasoning algorithms.
- Develop high performance reasoning techniques and knowledge representation methods that handle rapid changes in information, as well as uncertainty.
- Develop hybrid and integrated reasoning tools to overcome limitations and shortfalls in current reasoning techniques.
- Explore scalable, high-performance reasoning focusing on propositional systems and methods for temporal reasoning with uncertainty.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Evaluate algorithms to find the Nash equilibrium solution and/or the dominant plan from a given set of plans for a variety of reasoning tasks such as effective coalition formation.
- Develop strategic reasoning tools to aid decision-making in complex environments, systematically incorporating information, incentives and goals in a distributed environment.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE February 2004		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research			R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01				
COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Electronic Sciences ES-01	17.568	26.449	25.465	21.809	22.678	25.416	27.118

(U) **Mission Description:**

(U) This project seeks to continue the phenomenal progress in microelectronics innovation that has characterized the last decades by exploring and demonstrating electronic and optoelectronic devices, circuits and processing concepts that will: 1) provide new technical options for meeting the information gathering, transmission and processing required to maintain near real-time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near real-time; and 2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities. Research areas include new electronic and optoelectronic device and circuit concepts, operation of devices at higher frequency and lower power, extension of diode laser operation to new wavelength ranges relevant to military missions, development of uncooled and novel infrared detector materials for night vision and other sensor applications, development of innovative optical and electronic technologies for interconnecting modules in high performance systems, research to realize field portable electronics with reduced power requirements, and research addressing affordability and reliability. Additionally, electronically controlled microinstruments offer the possibility of nanometer-scale probing, sensing and manipulation for ultra-high density information storage "on-a-chip", for nanometer-scale patterning, and for molecular level analysis and synthesis. These microinstruments for nanometer-scale mechanical, electrical and fluidic analysis offer new approaches to integration, testing, controlling, manipulating and manufacturing nanometer-scale structures, molecules and devices.

(U) **Program Accomplishments/Planned Programs:**

	FY 2003	FY 2004	FY 2005
University Opto-Centers	10.083	12.131	8.572

(U) This program is dedicated to coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components. Such components are critical to enhancing the effectiveness of military platforms that provide warfighter comprehensive awareness and precision engagement. Topics researched include emitters, detectors,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

modulators and switches operating from infrared to ultraviolet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules. The University Opto-Centers Phase II program will facilitate and enhance interaction between the developers of cutting edge photonic device technology in the industry and academic researchers that exploit these devices for novel applications. Industrial participants benefit by getting feedback from potential users of their device technology as well as by ensuring that the graduates are trained in the latest device technologies.

(U) Program Plans:

- Evaluate novel methods for the design, fabrication and demonstration of chip-scale modules that integrate photonic, electronic and MEMS based technologies.
- Characterize the impact of these new technologies on applications in the areas of bio-photonics, optically addressed memory and on-chip optical interconnects.
- Fabricate and test individual chip-level sub-assemblies for later use in prototype development.
- Design and fabricate prototype modules using the system-on-a-chip approach.
- Develop testbeds capable of fully measuring and characterizing the mixed technologies implemented in the chip-scale components.
- Evaluate the performance characteristics of the prototype modules and determine the highest payoff dual use development paths.
- Identify and enlist industrial participants.
- Develop a process for competitive selection of Phase II university participants.
- Identify a common set of photonic devices most widely used/requested and make them immediately available for experimentation.

	FY 2003	FY 2004	FY 2005
Semiconductor Technology Focus Centers	6.158	5.500	10.000

(U) The Semiconductor Technology Focus Center Research program concentrates on exploratory and fundamental semiconductor research efforts that solve the most critical, long-term scaling challenges in the fabrication of high performance complex integrated circuits. This program will develop new design and fabrication approaches and will demonstrate technologies for reaching nano-scale device dimensions and hyper-scale integrated circuits that will meet future military needs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) Program Plans:

- Develop efficient platform-based design methodologies and low latency interconnect technologies for complex integrated circuits that have application in high performance signal processing and communications systems.
- Develop methods for physics-based simulations of performance of deeply scaled switching device structures and circuit architectures.
- Develop the interface methodology for efficient handling and compilation of design object information for complex military integrated circuits.
- Develop circuit architectures that reduce long interconnects.
- Develop novel device fabrication and integration approaches for deeply scaled transistors and architectures for high performance mixed signal circuits for military needs.

	FY 2003	FY 2004	FY 2005
Molecular Photonics(MORPH) (formerly Supermolecular Photonics Engineering)	0.000	5.168	6.893

(U) Large dendritic and other highly branched organic molecules offer great potential for active photonic applications. Three-dimensional molecular structure and shape can be engineered to orient and immobilize optically active substituents to achieve much higher electro-optic activity than with traditional polymer systems. The ability to engineer molecular structure, shape, energy transport, and chemical composition offers the potential for distinct electronic energy level engineering without the traditional semiconductor crystal lattice. This will allow more freedom to tailor electromagnetic response of individual molecules to achieve functionality not possible in semiconductors. Potential applications include: Direct conversion of sunlight to power ("optical antenna"), inversion-less lasers and electromagnetically induced transparency (coherent organic emitters, and slow light materials), high performance photorefractive materials for signal processing and holographic memory, optical limiters and saturable absorbers as well as high performance modulators.

(U) Program Plans:

- Model and simulate advanced structures for four classes of applications.
- Improve modeling capability for predicting macro functionality from nanostructure.
- Emphasize chemical synthesis.
- Address parameters such thermal stability, environmental chemistry tolerance (O_2, H_20, etc) and photochemistry.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

- Fabricate initial devices; continue modeling maturation.
- Final material synthesis, prototype device fabrications, characterization and demonstration.

	FY 2003	FY 2004	FY 2005
Advanced Photonics Research	1.327	2.450	0.000

(U) Program Plans:

- This program continues research in photonic composites and device fabrication.

	FY 2003	FY 2004	FY 2005
Photonics Technology Access Program (PTAP)	0.000	1.200	0.000

(U) The PTAP program will facilitate and enhance interaction between the developers of cutting edge photonic device technology in the industry and academic researchers that exploit these devices for novel applications.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE February 2004		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research			R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01				
COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Materials Sciences MS-01	55.776	47.936	31.036	23.485	23.451	23.428	23.404

(U) Mission Description:

(U) This project provides the fundamental research that underpins the development of advanced nanoscale and bio-molecular materials, devices and electronics for DoD applications.

(U) Program Accomplishments/Planned Programs:

	FY 2003	FY 2004	FY 2005
Nanoscale/Bio-molecular and Metamaterials	7.912	8.486	14.051

(U) The research in this thrust area exploits advances in nanoscale and bio-molecular materials, including computationally based materials science, in order to develop unique microstructures and properties of materials. This includes efforts to develop the underlying physics for the behavior of materials whose properties have been engineered at the nanoscale (Metamaterials) level.

(U) Program Plans:

- Develop theoretical understanding and modeling tools for predicting novel metamaterial structures that exhibit superior microwave and magnetic properties for DoD electric drive and propulsion, power electronics, antenna, and radar applications.
- Develop algorithmic approaches for predicting properties and structure of nano-scale and meta-materials using first principles/quantum mechanical methods with higher accuracy and reduced computational complexity.
- Couple the algorithmic approaches to methods that extract parameters for simulation of materials at larger spatial scales while conducting experiments to verify/validate the predicted properties at all spatial scales.
- Explore fundamental behavior of nanostructured materials that display quantum and/or non-equilibrium behavior.
- Exploit an understanding of properties that are dominated by surface behavior to develop materials with increased thermal conductivity, biocidal properties, and phonon capture.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Develop advanced image detector materials to instantly and simultaneously detect one structural (computed tomography) and two functional (position emission tomography and single photon emission tomography) images of medical and life science interest.
- Demonstrate materials capability to allow multimodal imaging system with two orders of magnitude increased scan speed and detection for ultra-rapid baggage screening and non-destructive testing and evaluation.

	FY 2003	FY 2004	FY 2005
Engineered Bio-Molecular Nano-Devices and Systems	5.000	7.200	10.985

(U) This program seeks to develop and demonstrate engineered bio-molecular nano-scale devices that enable real time observation and analysis of bio-molecular signals thus enabling single molecule sensitivity with the simultaneous exploitation of the temporal domain (i.e., stochastic sensing). Arrays of such devices will enable an order of magnitude (10 to 100X) reduction in the time required for analysis and identification of known and unknown (engineered) molecules.

(U) Program Plans:

- Engineer hybrid biological/inorganic device architectures that optimize compatibility and information transfer between biological and non-biological materials with single molecule sensitivity.
- Develop new and innovative technologies in the areas of device architecture, design, interconnection, fabrication and integration of organic and inorganic materials to enable measurement of time constants of single molecule events.
- Develop techniques to perform direct, dynamic, stochastic and combinatorial analysis of bio-molecular signals in order to characterize unique molecular signatures based on such analysis (i.e., automatic recognition) of various biological/chemical targets.

	FY 2003	FY 2004	FY 2005
Spin Dependent Materials and Devices	14.000	12.000	6.000

(U) The major emphasis of this thrust is to provide the theoretical and experimental underpinnings of a new class of semiconductor electronics based on spin degree of freedom of the electron, in addition to (or in place of) the charge. Not only will this class of electronics lead to novel and faster electronic devices, but it will also serve as one of the key technology enablers for quantum communications and quantum computation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

(U) Program Plans:
- Demonstrate a room temperature spin light emitting diode (spin LED).
- Demonstrate a spin transistor with significant gain.
- Demonstrate spin coherent optical devices operating at speeds approaching a terahertz.
- Demonstrate a phase coherent and phase controlled device operating above 10 GHz.
- Demonstrate a scaleable spin-based implementation for quantum logic gates.

	FY 2003	FY 2004	FY 2005
Spin Electronics	15.000	12.750	0.000

(U) Program Plans:
- Continue to explore new directions in spin electronics to determine areas important for continued DoD investment.
- Continue exploration of the benefits of using the spin degree of freedom in organic electronics.
- Continue to study spin dynamics in nanostructures.
- Continue exploring new materials and structures that exhibit spin dependent behavior.

	FY 2003	FY 2004	FY 2005
Ultra Performance Nantechnology Center	3.000	0.000	0.000

(U) Program Accomplishments:
- Continued efforts in ultra-performance nanotechnology and identified specific DoD targets.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

	FY 2003	FY 2004	FY 2005
Joint Collaboration on Nanotechnology	1.800	1.700	0.000

(U) Program Plans:
- Continue to investigate the potential enabling impact of recent nanotechnology material developments in biotechnology applications.

	FY 2003	FY 2004	FY 2005
Center for Nanostructure Materials	0.400	0.000	0.000

(U) Program Accomplishments:
- Initiated efforts to develop novel nanostructured materials.

	FY 2003	FY 2004	FY 2005
Nanotechnology Research and Training Facility	2.300	0.000	0.000

(U) Program Accomplishments:
- Initiated a new center to provide a multi-disciplinary research environment and training facility for graduate.

	FY 2003	FY 2004	FY 2005
Life Science Education and Research	5.000	0.000	0.000

(U) Program Accomplishments:
- Explored the potential of a diverse array of multidisciplinary life science programs, ranging from molecular biology to ecology to contribute new technological capabilities for defense.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

	FY 2003	FY 2004	FY 2005
Molecular Electronics	1.364	0.000	0.000

(U) Program Accomplishments:
- Initiated design concepts for the integration of molecular scale electronics for molecular circuits.

	FY 2003	FY 2004	FY 2005
Joint Collaboration on Nanotechnology and Biosensors	0.000	3.000	0.000

(U) Program Plans:
- Fund a consortium of university researchers to investigate the potential application of nanotechnology for advanced biosensor developments.

	FY 2003	FY 2004	FY 2005
Nano- and Microelectronics	0.000	2.800	0.000

(U) This research will provide the tools for developing molecular electronics technologies to enable construction of electronic circuits at the nanometer-scale for computation.

(U) Program Plans:
- Demonstrate computing with molecular-scale structures – i.e., nanometer-scale structures.
- Characterize and organize nanometer-scale materials.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2004
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

(U) Other Program Funding Summary Cost:

- Not Applicable.